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WHEAT AND RYE

By

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Dr. C. A. Zavitz.

INTRODUCTION.

Wheat is used more extensively as human food than any other cereal. Rye constitutes the main bread grain of more than one-third of the inhabitants of Europe. Both are particularly rich in nutritive materials, and no other grains contain a gluten which is capable of expanding and forming light porous bread. Flour for bread production can be made from these two cereals either separately or in combination with each other or with flour from other grains. Both wheat and rye can be easily grown, readily transported and conveniently stored when necessary.

Fig. 1.—A partial view of the experimental grounds at the Ontario Agricultural College, showing plots of wheat, etc.

It is claimed that wheat was used as food by the Chinese 2,700 years before the Christian era, by the Egyptians at even an earlier date, and that it was cultivated by the Swiss lake dwellers and by other pre-historic races. There appears to be no authentic record of wheat growing wild and naturally re-seeding itself without the help of man. The culture of rye, although not as old as wheat, traces back for more than two thousand years. It is doubtful if rye can be found in the wild state at the present time.

Although rye can be grown under a variety of conditions, wheat has a greater range of cultivation throughout the world than any other cereal. It is now grown successfully near the Arctic circle as well as in the tropics. It is produced most abundantly, however, in the temperate climates.

CROP PRODUCTION.

In the average for the three years immediately before the war, the crop acreages of the most important agricultural nations of the world, excepting China, for which statistics are not available, are given in the following order: United States, Russia, India, Germany, Austria-Hungary, Argentina, France, Italy and Canada. Those countries which have the greatest crop acreage per capita are Argentina, Canada, the United States, the Russian Empire and France. Based largely on Danish experiments, and taking as a criterion the most important food crops, the estimated production per capita in terms of wheat for each of the leading crop-producing countries is as follows:

Countries.	Bushels per capita.	Countries.	Bushels per capita.
Canada	70.4	France	17.9
Argentina	56.3	Russian Empire	17.4
United States	45.3	Italy	9.6
Australia	24.7	India	7.3
German Empire	21.3	Great Britain and Ireland	5.6
Austria-Hungary	21.0		

According to these estimates, determined from reports of the United States Department of Agriculture, regarding the principal crop-producing countries of the world, Canada comes ninth in total crop acreage and third in crop acreage, per unit, of population. Canada stands at the very top of the list, however, of the leading countries of the world in production, per capita, of the essential food materials from farm crops. Skilled agricultural labour in this country is, therefore, at a great premium as a factor in the production of a greater amount of food for export.

WHEAT PRODUCTION.

The total wheat production of the world reaches nearly four billion bushels annually. The four most important wheat regions are Southern Europe, Central North America, India and Argentina. Of these areas the one in Southern Europe is the most extensive. Europe produces about twice as much wheat as North America, while India produces about ten and Argentina four per cent. of the wheat crop of the world.

According to the revised statistics for 1917, Canada produced 231,730,200 bushels, and the United States 650,828,000 bushels of wheat. It is stated that under normal conditions, in estimating the amount of surplus wheat available for export, an allowance should be made from the total wheat production of about 5.5 bushels per capita for domestic consumption, seven pecks per acre for seed purposes, and ten per cent. loss in cleaning and for grain of unmarketable quality. Taking these points into consideration, we find that in 1917 although Canada produced only about one-third as much wheat as the United States, it had a normal surplus for export approximately six times as great as that of the American Union. This gives an explanation as to why it is that the allied powers are placing so much importance on the wheat production of Canada, particularly during the period of great scarcity of essential food materials.

The wheat crop of Ontario, in 1917, was 75 per cent. of the average annual crop for the past thirty-six years, and 88 per cent. for the past five years. The total production of wheat in Ontario in the past year was slightly more than sufficient to meet the demands at home, and was about equal to the surplus production of wheat in the United States over home requirements. If the Province of Ontario could double its wheat acreage, the normal surplus for export from this Province alone would be about equal to that from the United States in 1917.

The price of wheat in England, from 1259 to 1915, varied from 9 cents to $3.85 per bushel, the former price occurring in the years 1287, 1288 and 1509, and the latter in the year 1812. The earliest date at which wheat reached $1 per bushel was 1595. In the one hundred and twenty-two years, from 1764 to 1885 inclusive, wheat did not go below $1 per bushel, and in each of thirty years it reached from $2 to $3.85 per bushel. From 1886 until the beginning of the present war, winter wheat was less than $1 per bushel, excepting in the years 1891, 1898, 1909 and 1912. The lowest price in this period was 69 cents per bushel in 1894.

BOTANICAL CLASSIFICATION OF WHEAT.

According to most authorities, wheat is divided botanically into eight different types or species. Representatives of all of these types have been under experiment at the Ontario Agricultural College. Only four of the species, however, have been represented by varieties in general cultivation throughout the Province. The following table gives the average yield, in pounds of grain per acre, for ten years, of a leading variety of wheat representing each of the eight different species:

Name of Species.	Names of High Yielding Varieties.	Average yield in pounds of Grain per Acre. (10 years).
1. Common (*Triticum vulgare*)	Dawson's Golden Chaff Winter Wheat	2,586
2. Club (*Triticum compactum*)	Herison Bearded Spring Wheat	1,902
3. Hard or Flinty (*Triticum durum*)	Roumania Spring Wheat	2,238
4. Turgid or Toulard (*Triticum turgidum.*)	Seven Headed Spring Wheat	1,686
5. Polish (*Triticum polonicum*)	Polish Spring Wheat	1,308
6. Emmer (*Triticum dicoccum*)	Common Emmer	2,644
7. Spelt (*Triticum s*	Red Spelt	1,915
8. Einkorn (*Triticum* *ococcum*).	Einkorn	1,780

In threshing the varieties comprising the first five species, there is a clear separation of the chaff and the grain. When threshing the varieties of the last three species, however, the heads simply break into the separate spikelets and the grain is still enclosed in the chaff, the chaff forming from twenty to thirty per cent. of the weight as given in the accompanying table. The Common wheat (*Triticum vulgare*) includes the greater number of the varieties of both the winter wheats and the spring wheats which are grown in general cultivation throughout Ontario for bread production. These varieties may have bearded or beardless heads, white or red chaff, and white or red grain. The Club wheat (*Triticum compactum*) is not very different, botanically, from the first-named species, but the heads are very compact and the varieties show marked constancy and uniformity. This type is represented in Ontario to a limited extent by the Herison Bearded spring wheat. The Flinty, Turgid and Polish types furnish wheat which is particularly suited for the manufacture of macaroni, and is not used so extensively for bread production. The hard or flinty type is represented by the Wild Goose variety of spring wheat which is grown quite extensively in some parts of the Province. Emmer is a large yielder of grain which is grown to a limited extent in Ontario as a feed for farm stock. It has been improperly called Spelt by a number of the seedsmen. Both Spelt and Einkorn have given results which will not justify their use on the farms of this Province.

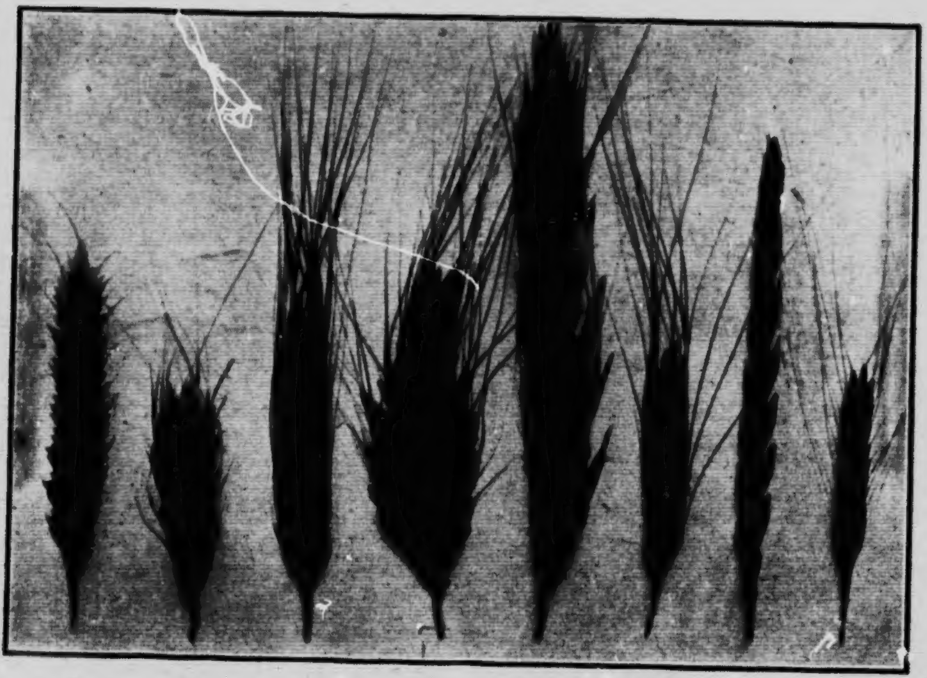

Fig. 2.—Eight Species of Wheat as given in connection with the accompanying Botanical Classification.

POPULAR CLASSIFICATION OF WHEAT.

But few farmers in Ontario pay much attention to the botanical classification of wheat. There are, however, a number of popular classifications recognized by all of the growers, such, for instance, as the division into spring and fall, bearded and beardless, white and red grain, white and red chaff, and hard and soft grain. For the purpose of this bulletin, particular attention will be given to varieties of winter wheat, varieties of spring wheat for flour production, varieties of macaroni spring wheat, emmer and spelt for feed production and miscellaneous varieties.

VARIETIES OF WINTER WHEAT.

About two hundred and ninety named varieties of winter wheat and many selections and crosses have been grown under experiment at the Agricultural College within the past twenty-eight years. Nearly all of the varieties have been carefully tested in each of five years, after which the inferior kinds have been discarded and those which have given the best results have been continued in the experiments. Of the named varieties, fourteen have been grown in each of twenty-two years, and the results of these are of special value. The following table gives for each of these fourteen varieties the average weight per measured bushel for twenty-one years and the average yield of both straw and grain per acre for the twenty-two year period:

Variety.	Color of Grain.	Pounds per Measured Bushel. 21 years.	Yield per Acre. Average 22 years. Tons Straw.	Yield per Acre. Average 22 years. Bushels Grain.
Dawson's Golden Chaff	White	59.9	2.9	50.2
Imperial Amber	Red	61.1	3.1	47.2
Early Genesee Giant	White	60.1	3.0	45.9
Egyptian Amber	Red	61.5	3.1	45.5
Early Red Clawson	Red	58.9	2.8	45.4
Rudy	Red	61.4	2.7	44.5
Tasmania Red	Red	61.6	2.8	43.6
Tuscan Island	Red	61.2	2.8	43.4
Geneva	Red	62.0	3.0	43.1
Kentucky Giant	Red	61.0	2.8	43.0
Turkey Red	Red	61.3	2.7	42.7
McPherson	Red	61.9	2.6	41.9
Bulgarian	White	60.7	2.8	41.8
Treadwell	White	59.8	2.8	41.3

The average results of the fourteen varieties for the whole period of the experiment are as follows: Yield of grain per acre, 44.3 bushels; yield of straw per acre, 2.9 tons; and weight per measured bushel, 60.9 pounds. In the last twenty-two years, the lowest average yields per acre of the fourteen varieties mentioned have been 20.2 bushels in 1912, 25.6 bushels in 1917, [illegible] bushels in 1895, 32.0 bushels in 1908, and 34.1 bushels in 1904; and the highest yields have been 66.7 bushels in 1900, 61.6 bushels in 1902, 60.5 bushels in 1903, and 58.9 bushels in 1915. In 1899 and 1901 the results were so poor that no satisfactory tabulated returns could be made.

The Dawson's Golden Chaff is still the most extensively grown variety of winter wheat in Ontario, according to information obtained through an extensive correspondence with practical farmers. This variety, in the results at Guelph for twenty-two years, has given an annual average yield of grain per acre of exactly three bushels over the next highest yielding variety and of practically nine bushels per acre over the lowest yielder of the fourteen varieties included in the test. The Dawson's Golden Chaff was originated in Ontario thirty-seven years ago. It produces a very stiff straw of medium length, beardless heads with red chaff and white grain which weighs about the standard per measured bushel. It is probable that the Dawson's Golden Chaff is improving slightly in bread production. According to the last Annual Report, giving the results of the competitions in standing field crops in Ontario, twelve varieties of winter wheat were entered in connection with the different agricultural societies. The Dawson's Golden Chaff had fifty-eight per cent. of the entries and received sixty-eight per cent. of all the awards and seventy-one per cent. of the first prizes.

Thirty-four varieties of winter wheat have been under test at the College for at least five years. In the five years' experiment, the highest average yields in bushels of grain per acre of the named varieties have been produced by Imperial Amber, 45.8; Kharkov, 45.7; Gillespie Red, 45.2; McBean's Golden Chaff, 45.1; Tuscan Island, 44.9; Grand Prize, 44.7; and American Banner, 44.6. The Imperial Amber possesses bearded heads, red chaff and red grain; the Kharkov bearded heads, white chaff and red grain; and the Gillespie Red beardless heads, white chaff and red grain. The heaviest weights of grain in pounds per measured bushel, in the five years' test, have been produced by Theiss, 62.5; Kharkov, 62.4; Banatka, 62.0; Turkey Red and Virginia Miracle, each 61.9; Tuscan Island, 61.7; and Imperial Amber, 61.5.

In the average results of the five years' test Theiss, Kharkov, Tuscan Island, Yaroslaf and Banatka were the freest from rust, and Tystofte Smaa and McBean's Golden Chaff were the most severely affected by this fungus. Banatka, Theiss, Crimean Red, Geneva and Kharkov were the weakest in the straw, and Dawson's Golden Chaff, American Banner, Imperial Amber, Michigan Amber, McPherson and Scott were the earliest to reach maturity.

SEED SELECTION.

The results of a duplicate test made in each of six years at the College with selections of winter wheat for seed purposes, show an average annual increase in yield per acre of 6.8 bushels from large as compared with small seed, of 7.8 bushels from plump as compared with shrunken seed, and of 35.6 bushels from sound as compared with broken seed. For this experiment a uniform number of seeds of the different selections was used on the separate plots. The figures here given represent the influence from single and not from continuous selections, and the experiment was repeated in each of six years in order to get average and reliable information. The detailed results show that the large plump seed gave a greater yield per acre than either the small plump seed or the shrunken seed in each year of the test.

Owing to exceptionally wet seasons, winter wheat sometimes becomes sprouted before it is harvested. In each of two years, when winter wheat was sprouted in the fields, the germination tests of the threshed grain were afterwards made. The following results show the average percentage of germination from each selection: skin over germ, unbroken, 94; skin over germ, broken, 76; sprouts, one-quarter inch long, 30; and sprouts one inch long, 18. Not only were the sprouted seeds low in germination, but the plants produced were very uneven in growth.

Each of two varieties of winter wheat were harvested at each of five stages of maturity, one week being allowed between each two cuttings, and the grain produced from the different cuttings was used for sowing. The seed which was allowed to become thoroughly ripened before it was cut produced a slightly greater yield of both grain and straw, and a heavier weight of grain per measured bushel than that produced from wheat which was cut at any one of the four earlier stages of maturity in the average tests for five years.

The information here presented shows the great importance of using large, plump, sound, well-matured grain of a high percentage germination and of a uniform growth for crop production.

TESTING THE QUALITY OF WHEAT.

The quality of wheat is determined largely by the variety used and by the climatic conditions under which the wheat is produced. It is practically impossible, by means of manures and fertilizers alone, to materially increase or decrease the starch or gluten contained in wheat. For the production of pastry, breakfast foods, etc., the soft varieties of wheat grown in comparatively moist climates are used. For the highest results in bread production, however, it is important to grow in a comparatively dry climate those varieties of wheat which naturally produce a high percentage of gluten. Wheat differs in composition from all other cereals in that its gluten is composed of two proteids, gliadin and glutenin. This gives flour its bread-making value.

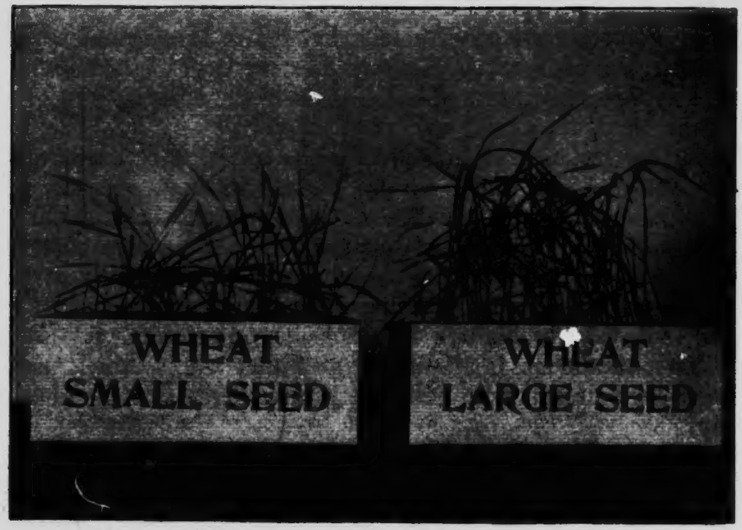

Fig. 3.—Young growth of Plants from an equal number of small seed and of large seed of winter wheat.

Some indication of the quality of wheat for bread production may be gleaned from the weight per measured bushel, from the transparency of the grain, from the hardness of the kernels, and from the quantity and the quality of the gluten secured from chewing the grain. Certain information is also gleaned from the chemical composition of wheat. The most accurate and reliable information, however, is secured by grinding the grain and by converting the flour into bread.

In each of the past ten years the varieties of winter wheat grown under experiment, in the Field Husbandry Department, have been carefully tested for bread production in the Bakery branch of the Chemical Department of the College. Those varieties of winter wheat which produced the largest loaves of bread from equal quantities of flour in the average tests, made in each of ten years, are given in the following order: Yaroslaf, Banatka, Crimean Red, Tuscan Island, Buda Pesth, Tasmania Red, Egyptian Amber, Kentucky Giant, Rudy, Treadwell, Bulgarian, Geneva and Turkey Red; and those which produced the smallest loaves of bread are the Eerly Red Clawson and the Abundance. In average bread production for five years of each of twenty-eight varieties, the largest loaves were produced by Yaroslaf, Buda Pesth, Banatka, Bulgarian, Egyptian Amber, Tuscan Island, Kentucky Giant, Tasmania Red, Turkey Red, Crimean Red, Geneva and Kharkov; and the smallest loaves by Abundance and Grand Prize.

IMPROVEMENT OF WHEAT BY PLANT SELECTION.

The choice of the best plants is the keynote of selection, and selection is the principal factor of plant improvement.

Mass Selection.—The process of selecting from a field the best heads or the best plants, and of using collectively for seed the grain thus collected, is termed "mass selection." If the process is repeated by selecting the best plants from year to year, the process is spoken of as "continuous mass selection." This method has been used by some of the experiment stations, and is the method in use by the members of the Canadian Seed Growers' Association at the present time. This process applied to cereals for three years in succession, under regulations and inspection, furnishes grain which is eligible for sale as pedigreed seed when offered in sealed sacks.

Individual Plant Selection.—Undoubtedly, the most effectual method of improvement by selection of farm crops is worked on the basis of the individual plants. This method may be operated in large fields sown in the ordinary way or in nursery plots planted by hand.

An interesting instance in individual plant selection is the development of the Dawson's Golden Chaff winter wheat. Robert Dawson, a farmer living near Paris, Ontario, had a field of the White Clawson winter wheat in the year 1881, which was badly lodged. In walking over the field, Mr. Dawson observed a plant standing upright in the midst of the lodged grain. He carefully saved this one plant and sowed the seed in the autumn. In a comparatively short time he had sufficient seed, not only for his own requirements, but also for sale to his neighbors. The Dawson's Golden Chaff variety of winter wheat, which possesses very stiff straw, has been grown more extensively throughout Ontario than any other single variety.

From a nursery plot of the Dawson's Golden Chaff winter wheat selections were made at the College. In the experiments of the past five years, however, the Dawson's Golden Chaff and the special selection of this variety have each given an average of 44.5 bushels per acre. This seems to confirm the idea that it is exceedingly difficult to improve a variety of grain which has recently been started from a single seed unless changes have occurred either as mutations or as exceptional natural cross-fertilizations.

In a nursery plot of the Imperial Amber, however, a selected strain has been obtained which, in the average of five years, has surpassed the original variety by 3.9 bushels per acre per annum.

HYBRIDIZATION.

With the object of originating better varieties of winter wheat than those already in cultivation, crosses have been made between Dawson's Golden Chaff and some of the varieties of particularly high quality for bread production, such as Tasmania Red, Crimean Red, Turkey Red, Buda Pesth, Bulgarian and Imperial Amber. In the average tests for the past five years, each of nine crosses between the Dawson's Golden Chaff and the Tasmania Red, the Bulgarian, and the Turkey Red has surpassed, in average yield of grain, the highest yielder of all the named varieties.

THE O.A.C. NO. 104 VARIETY OF WINTER WHEAT.

A cross which has been made at our College between the Dawson's Golden Chaff and the Bulgarian has furnished a new variety of winter wheat which is very promising. In the past six years it has produced an average annual yield of grain per acre of 45.0 bushels, while the Dawson's Golden Chaff for the same period has produced 40.8 bushels, and the Bulgarian 37.5 bushels. It will, therefore, be seen that the O.A.C. No. 104 has surpassed each of its parents in productiveness. It has given a grain which is almost equal to the Bulgarian for bread production.

The O.A.C. No. 104 variety is a vigorous grower, with a comparatively stiff straw. The grain is white, and the variety resembles the Dawson's Golden Chaff in being beardless and the Bulgarian in having a white chaff. This variety was distributed for the first time over Ontario in connection with the co-operative experiments in the autumn of 1916. The following gives the average results of co-operative experiments conducted on twenty-five farms throughout Ontario within the past year:

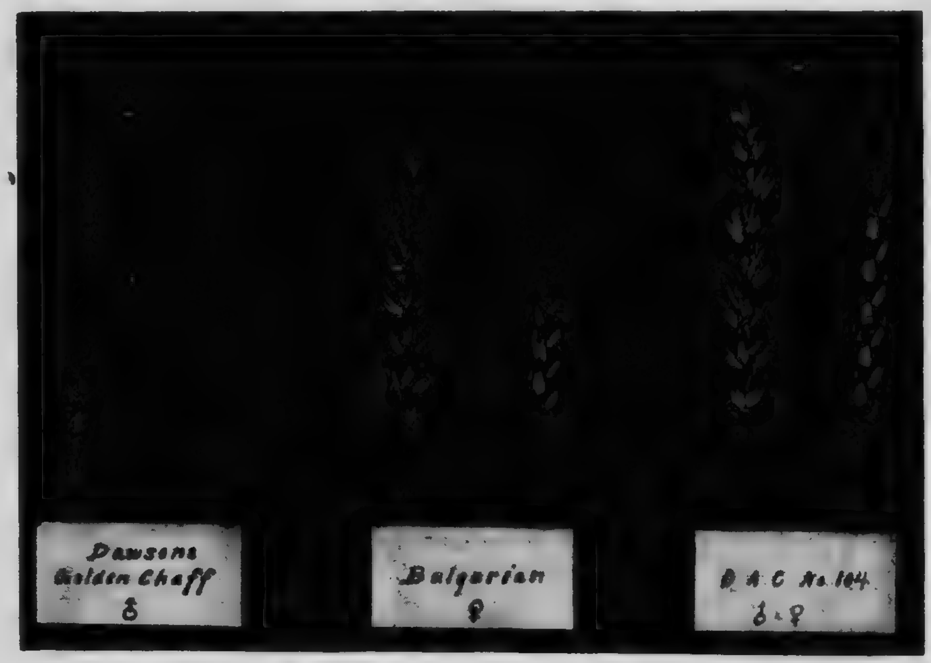

Fig. 4.—The O. A. C. No. 104 variety of Winter Wheat with its two parents, the Dawson's Golden Chaff and the Bulgarian.

Varieties.	Comparative Value or Popularity.	Yield per Acre.	
		Straw (tons)	Grain (bus.)
O. A. C. No. 104	100	1.78	23.69
Imperial Amber	94	1.78	22.91
Dawson's Golden Chaff	94	1.41	21.47
Kharkov..............................	48	1.72	19.34
Yaroslaf.............................	55	1.79	17.57

It will be seen in the average results of the twenty-five experiments that the O.A.C. No. 104 variety of winter wheat came at the top of the list both in popularity and in yield of grain per acre. In past years the Imperial Amber has been one of the closest rivals of the Dawson's Golden Chaff in yield of grain per acre in the co-operative experiments throughout the Province.

VARIETIES OF WINTER WHEAT GROWN IN COMBINATION.

In each of five years an experiment was conducted at the College by growing the Dawson's Golden Chaff and the Turkey Red varieties of winter wheat separately and in combination. The experiment was duplicated each year by sowing the Michigan Amber and the Early Genesee Giant in the same way. When two varieties were grown in combination, exactly one-half the amount of seed was sown of each as was used of the same varieties when sown separately, therefore, a uniform weight of seed was sown on all the plots. The results show that the Dawson's Golden Chaff surpassed the Turkey Red in yield per acre in each year of the test, and that the yield per acre of the mixture of the two varieties occupied an intermediate position between the yields of the varieties grown separately. With two slight exceptions, the mixture of Michigan Amber and Early Genesee Giant gave a yield per acre intermediate between that of the two varieties grown separately. In the average of the five years' experiments, varieties of winter wheat gave practically the same results when sown in combination as when sown separately. There is apparently no advantage in growing different varieties of winter wheat in combination.

SOIL, ROTATION, CULTIVATION AND FERTILITY.

Winter wheat can be grown successfully on a variety of soils. It thrives particularly well, however, on a rich loam containing disintegrating limestone and decaying vegetable matter. Fertile clay soils, when well drained, usually give satisfactory results in wheat production.

In the crop rotations followed in Ontario, winter wheat occupies an important place. It does particularly well on a bare summer fallow or after beans, peas or sod, and especially after clover. Wheat makes a good nurse crop with which to seed down grasses and clovers. The clovers should be sown in the spring but the timothy and the other grasses could be sown either in the autumn or in the spring following.

In the experiments at the College, winter wheat which has been grown on clover and on alfalfa sods has yielded much better than that which has been grown on timothy and on orchard grass sods.

Sod or stubble land intended for winter wheat should be ploughed about the first of August. If the soil is dry it should be rolled immediately and harrowed soon afterwards. The land should be worked on the surface occasionally until seeding time. This helps to retain the moisture, mellow the soil and furnish a good seed bed.

An experiment with different preparations of land for winter wheat was conducted in duplicate in each of four years, making eight separate tests in all. In each test two plots were summer fallowed and three plots were sown with crops to be used as green manure. The crops employed were field peas, buckwheat and rape. In the latter part of July, or in early August of each year, the crops were ploughed under as green manure and the land was worked on the surface occasionally during the month of August. In each test one of the bare fallowed plots received farmyard manure at the rate of twenty tons per acre before seeding time. The winter wheat was sown each year during the first week in September. The following table gives the average results of the eight tests conducted in the four-year period:

Soil Preparation.	Weight per Measured Bushel. Average four years.	Yield per Acre.	
		Straw (tons) Average four years.	Grain (bus.) Average four years.
Bare Summer Fallow and 20 tons Barnyard Manure, per acre	61.2	2.8	40.9
Bare Summer Fallow	60.9	2.1	33.8
Field Peas ploughed under	60.8	2.2	36.1
Buckwheat ploughed under	60.7	1.7	29.6
Dwarf Essex Rape ploughed under	60.5	1.8	30.4

As would naturally be expected, the bare summer fallow which received 20 tons of barnyard manure per acre gave the highest yield of grain, the average being 40.9 bushels, which was practically seven bushels per acre more than was produced from the land which was summer fallowed but which received no manure. One of the interesting features of this experiment is the fact that land on which field peas were used as a green manure gave an average annual yield of 6.5 bushels per acre more than land on which buckwheat was used for ploughing under. In each year of the experiment the field peas surpassed the buckwheat as green manure, and in three out of the four year rape gave a slight increase over buckwheat when ploughed under. The crops of buckwheat and peas were good in each of the four years, but the rape was not quite a full crop in one or two of the years. The superior quality of the field peas, as compared with the buckwheat as a green manure, is likely due to the fact that the peas are a leguminous crop and have the power of assimilating the free nitrogen of the atmosphere and of adding this increased fertility to the soil when the crop is ploughed under as a green manure.

In the co-operative experiments conducted through the medium of the Experimental Union with different fertilizers applied in the autumn to winter wheat, the average yields in bushels of grain per acre for eight years were as follows: Mixed fertilizer, 24.1; nitrate of soda, 22.7; muriate of potash, 22.3; and superphosphate, 22.4. On similar land, cow manure, at the rate of 20 tons per acre, gave an average yield of 26.3, and the land which received neither fertilizers nor manure gave an average of 18.9 bushels per acre. The superphosphate was applied at the rate of 320 pounds and the muriate of potash and the nitrate of soda each 160 pounds per acre. The mixed fertilizer consisted of one-third of the quantity of each of the other three fertilizers here mentioned.

In each of three other years the co-operative experiment of fertilizers with winter wheat was the same as in the eight-year test previously referred to, except that the fertilizers were applied in the spring instead of in the autumn of the year. From the spring applications, the land which received the mixed fertilizer gave the highest average yield, and the unfertilized land the lowest average yield of grain, the difference in favor of the former being 7.5 bushels per acre per annum.

The mixed fertilizer, therefore, when applied at the rate of 213 pounds per acre, either in the fall or in the spring, increased the yield of winter wheat from 5.2 to 7.5 bushels per acre over the unfertilized land.

The cost of the fertilizers used in this experiment would be approximately from $4 to $5 per acre under normal conditions.

As the result of the co-operative experiments conducted on average soils throughout Ontario, the mixed fertilizer, as previously described, when used with winter wheat, gave an increase of grain per acre of 5.2 bushels at a cost of 82 cents per bushel when applied in the autumn, and an increase of 7.5 bushels at a cost of 57 cents per bushel when applied in the spring.

In another experiment it has been found that nitrate of soda applied at the rate of 160 pounds per acre in the spring gave slightly over one bushel per acre more than a similar amount which was applied in the autumn. Nitrate of soda, at the rate of 160 pounds, increased the yield of wheat more than common salt at 400 pounds per acre when applied either in the autumn or in the spring.

Dates of Seeding, Seed per Acre, and Method of Sowing.

In each of six years an experiment was conducted by sowing two varieties of winter wheat on each of four different dates, allowing one week between each two dates of seeding. The soil and the cultivation were as uniform as it was possible to have them throughout the entire experiment. The following are the average results of the twelve separate tests conducted in the six-year period:

Dates of Seeding.	Weight per Measured Bushel (pounds) Average six years.	Yield per Acre.	
		Straw (tons) Average six years.	Grain (bus.) Average six years.
August 25-26	59.8	3.4	49.7
September 2-3	59.6	3.5	48.6
September 9	59.4	3.3	49.5
September 16-20	58.0	3.0	45.7

It will be seen that the dates of sowing had to be varied slightly owing to unfavorable weather conditions. The variation, however, was not greater than one day, excepting in the case of the last seeding, which did not take place until September 20th on one occasion. The results indicate that in Ontario winter wheat can be sown satisfactorily any time from the 25th of August to the 9th of September. After that date, however, the yield per acre is somewhat reduced. In two years of the experiment, winter wheat was also sown in duplicate plots on September 23rd and September 30th, and the results for each year show that there was still further reductions in yields per acre as the season advanced. The foregoing averages show not only a decrease in yield of grain per acre after the 9th of September, but also a decrease in both yield of straw per acre and weight of grain per measured bushel.

An experiment in sowing winter wheat at the rates of one bushel, one and one-half bushels and two bushels per acre, was conducted in duplicate in each of six years. The average results of the twelve distinct tests are as follows:

Seed per Acre.	Weight per Measured Bushel (pounds). Average six years.	Yield per Acre. Straw (tons) Average six years.	Grain (bus.) Average six years.
4 pecks	59.2	2.68	40.15
6 "	59.3	2.96	43.30
8 "	59.3	3.02	43.87

The heaviest seeding gave about one-half bushel per acre more than the second heaviest seeding, but it should be noted that the former required two pecks more seed than the latter. Grain prepared for sowing is more valuable than the same quantity of grain at the time of threshing. It will, therefore, be seen that after taking everything into consideration, one and one-half bushels per acre surpassed the lighter seeding and was fully equal or probably a little better than the heavier seeding.

Winter wheat, which was sown broadcast by hand, gave practically the same results as that which was drilled in with a machine, in the average of duplicate tests made in each of eight years. It should be understood that the land was in a good state of cultivation in every instance and that the amount of seed used was the same throughout. Had the land been dry and lumpy there would probably have been much better returns from the drill as compared with the broadcast seeding.

In an experiment conducted for two years, winter wheat sown from a tube drill in the ordinary way gave a larger yield than that which was cross drilled or than that which was sown from every second tube. In the cross drilling, one-half the amount of seed was sown in each of two directions, and when only one-half the tubes were used each tube received double the amount of seed. It will, therefore, be seen that the same rate of seeding per acre was used throughout.

THE EFFECT OF CUTTING WINTER WHEAT AT DIFFERENT STAGES OF MATURITY.

In the autumn of 1896, five plots of the Dawson's Golden Chaff and five plots of the Early Genesee Giant varieties of winter wheat were sown at the same time and under uniform conditions. In the summer of 1897 each variety of winter wheat was cut at five different stages of maturity. One week was allowed between each two cuttings. The first cutting took place about two weeks earlier than the wheat is usually cut throughout the Province. The third cutting, therefore, would represent pretty closely the condition in which winter wheat is cut on the average. Seed obtained from the different cuttings of the two varieties were secured and again sown under uniform conditions in the autumn of 1897. This process of cutting at different stages of maturity and of using the seed from the different cuttings has been repeated from year to year until the present time, with the exception of 1899, in which year the results were unsatisfactory. This experiment has, therefore, been conducted in full in each of twenty years, from which definite returns have been secured. The following table gives the average results of twenty years' tests in cutting two varieties of winter wheat at five different stages of maturity, also those for each of four periods of five years each:

Winter Wheat.	Cuttings.	1897-1902. Average 5 years.	1903-1907. Average 5 years.	1908-1912. Average 5 years.	1913-1917. Average 5 years.	1897-1917. Average 20 years.
Bushels of Grain per acre ..	1st	24.33	14.93	14.43	30.66	21.10
	2nd	46.13	33.70	28.42	42.02	37.57
	3rd	57.28	46.53	39.19	47.83	47.71
	4th	60.07	55.29	42.62	46.69	51.17
	5th	56.86	52.32	41.24	48.13	49.64
Weight of Grain per measured bushel	1st	44.18	36.84	44.56	55.17	45.19
	2nd	56.22	50.86	55.92	59.49	55.62
	3rd	59.56	57.88	60.63	60.25	59.58
	4th	59.10	59.21	60.70	60.07	59.77
	5th	57.97	59.02	59.81	58.34	58.79
Tons of Straw per acre	1st	4.31	4.15	2.56	2.96	3.49
	2nd	3.80	4.06	2.45	2.64	3.24
	3rd	3.40	3.86	2.22	2.59	3.02
	4th	3.47	3.61	2.12	2.52	2.98
	5th	3.33	3.28	1.90	2.56	2.79

The results here presented are interesting and are worthy of considerable study. It will be seen that in every instance the greatest yield of straw was produced from the grain which was cut when green, and that the yield of straw per acre decreased as the date of cutting advanced. In yield of grain per acre, however, the highest returns were secured from the grain which had been fully ripened. It is interesting to note that the fourth cutting produced winter wheat which weighed more per measured bushel than that which was cut one week later, as shown in the averages of each of the four periods. The determinations in weight per bushel throughout the whole period of the experiment were taken on an average of about ten or twelve days after the threshing had been completed. The whole experiment seems to point to the advantage of allowing winter wheat, grown in Ontario, to become pretty thoroughly ripened before it is cut.

TREATMENT OF WHEAT FOR SMUT.

Scientific investigations have been conducted at different institutions in a study of the best methods for destroying the various smuts which occur in grain crops. The Department of Field Husbandry has made careful tests for studying the practical application of some of the most highly recommended treatments. The results of these practical tests are of special value to Ontario farmers who are actually engaged in the growing of grain crops. The spores of the smuts correspond with the seeds of the grains and germinate and grow when the conditions of heat and moisture become favorable. The smuts are fungus plants which enter the tissues of other plants such as those of the cereals, where they live and grow, and finally produce smut pores. The reproductive organs of the loose smut of wheat may exist in the tissues of the ripened grains and it is, therefore, difficult to kill these spores and also to retain the vitality of the wheat. Although the hot water treatment may be effectual in killing these spores, it is rather difficult to carry out satisfactorily in ordinary farm practice. It is important to secure seed wheat from farms which are not infested with the loose smut of wheat. The spores of the stinking smut of wheat, also called Bunt, which attach themselves on the outside surfaces of the ripened grains, can be readily killed by treatment. This fact is of great agricultural and economic importance.

For five years in succession an experiment has been conducted at the Ontario Agricultural College for the prevention of the stinking smut in wheat. There were in all five treatments. In every instance one sample was left untreated as a basis of comparison. The experiment was conducted in duplicate each year. The seed grain was obtained each season from a known source, and where no treatment for smut had been attempted for several years previously. The following treatments were used throughout:

(a) *Untreated.*—One sample of winter wheat of each variety was left untreated in order that the influence of the various treatments might be better observed.

(b) *Immersion in Hot Water.*—The grain was placed in a bag and immersed in water at about 115 degrees F. Soon afterwards, it was placed in water which was kept at a temperature of between 130 degrees and 135 degrees F. The grain was occasionally stirred and was allowed to remain in the water for a period of fifteen minutes. It was then spread out on a clean floor to dry, where it was stirred occasionally.

(c) *Immersion in Bluestone Solution for Twelve Hours.*—The bluestone solution was made by dissolving one pound of bluestone in twenty-five gallons of water, and the grain was immersed in this solution for a period of twelve hours.

(d) *Sprinkling with Bluestone Solution.*—The solution was made by dissolving one pound of bluestone in ten gallons of water, which was used for sprinkling over the grain until it was thoroughly moistened, after being carefully stirred.

(e) *Immersion in Diluted Formalin.*—The solution of formalin (40 per cent. formaldehyde) used for the immersion process with wheat was made by pouring one-half pint of the formalin into twenty-one gallons of water, and the grain was immersed in this solution for a period of twenty minutes, during which time it was stirred occasionally.

(f) *Sprinkling with Diluted Formalin.*—One-half pint of formalin was poured into five gallons of water and the grain was sprinkled with this solution and stirred until it was thoroughly moistened.

After the treatments had been made for a few hours, and the grain had become sufficiently dried, it was carefully sown on separate plots. When the winter wheat was about ready to cut, it was carefully examined and the heads containing stinking smut were gathered and shelled. The rest of the crop was then threshed and again examined for any smut balls from heads which had been missed in the standing crop. The accompanying table gives the average results in percentage of grains of winter wheat affected with the stinking smut. Besides this information, the average yields of winter wheat per acre for five years are included:

Materials.	Percentage of Smut.						Average yield of grain per acre 5 yrs. (bus.)
	1st yr. test.	2nd yr. test.	3rd yr. test.	4th yr. test.	5th yr. test.	Average 5 yrs.	
(a) Untreated	3.6	9.8	.6	.0	6.8	4.2	38.0
(b) Hot Water	.0	.0	.0	.0	.0	.0	40.6
(c) Bluestone—12 hours	.0	.0	.0	.0	.0	.0	40.2
(d) Bluestone—sprinkled	.0	.2	.0	.0	.1	.1	41.1
(e) Formalin—immersed	.0	.0	.0	.0	.0	.0	43.8
(f) Formalin—sprinkled	.0	.0	.0	.0	.0	.0	36.8

The results here show that treatment (e) was not only effectual in killing the smut entirely, but it also was the means of giving the highest average yield of grain per acre of the various treatments used. The immersion process is so complete in its results that it does not need to be repeated every year, providing care is exercised to prevent a further introduction of the smut spores. In preparing wheat for treatment, care should be taken to separate the unbroken smut balls from the wheat, either by cleaning the grain or by placing the seed in water and removing the smut balls as they float on the surface. Not only is it necessary to treat the grain, but the formalin solution should be used to kill the smut spores which are lodged in the bins, on the barn floors, on the bags, in the grain drills or wherever the living spores have an opportunity of reinfesting the grain.

The sprinkling process is used by some farmers, but unless great care is taken the method is not as complete in destroying all of the smut, and as a result it is frequently necessary to treat the grain every year.

Further experimental work in treating grain for smut is now under way. This includes not only the hand methods, but also the use of some machines which are manufactured for this purpose. Different strengths of solution for the sprinkling process are being used. Ten different treatments were tested in duplicate in 1917.

As a result of the past work which we have conducted at the College, we have obtained very satisfactory returns from immersing the winter wheat for twenty minutes in a solution made by mixing one pint of formalin with forty-two gallons of water. This treatment is easily applied, and is comparatively cheap. It has been effectual in completely killing all of the smut spores and in producing the largest average yield of wheat per acre of all the treatments used.

SPRING WHEAT.

According to the Bureau of Industries for Ontario, there were 182,957 acres of spring wheat in this Province in 1917. This is an increase of 38,652 acres over the year previous. The total production of spring wheat in Ontario, in 1917, was 1,465,555 bushels greater than that of the year previous. The average annual yields of spring wheat per acre in Ontario for the last thirty-six years, when divided into four periods of nine years each, are as follows:

Periods.	Years.	Annual yield per Acre (bus.)
1882-1890	9	15.3
1891-1899	9	15.5
1900-1908	9	17.6
1909-1917	9	18.2

It will be seen that as far as can be learned from the statistics of the Bureau of Industries for Ontario, there has been a gradual increase in yield of spring wheat per acre over the past thirty-six years. The average annual yield per acre for the last three years has been greater than that of any other three consecutive years since 1882, which is the full length of time for which data has been obtained.

Spring wheat is grown in every county and district of the Province, varying in area from 52 acres in Elgin county, which has the lowest, to 33,239 acres in Renfrew county, which has the highest. Those counties of the Province which grew the greatest number of acres of spring wheat in 1917 are in the following order; 1, Renfrew; 2, York; 3, Ontario; 4, Durham, 5, Carleton; 6, Lanark; 7, Northumberland; 8, Victoria; 9, Simcoe; and 10, Grey.

By multiplying the average yield per acre in Ontario for the past ten years of spring wheat, barley and oats, by the present price per bushel, we obtain the following figures:

Crops.	Average Annual Bushels per Acre. 10 years. 1908-1917.	Present Price per Bushel.	Average Annual Value of Grain per Acre.
Spring Wheat	18.0	$2.10	$37.80
Barley	29.5	1.20	35.40
Oats	35.7	0.75	26.78

The world is calling loudly for food materials, and especially for wheat. This is a special opportunity for Ontario to be of real service to humanity.

VARIETIES OF SPRING WHEAT.

Twenty-one varieties of spring wheat, exclusive of Emmer, Spelt and Einkorn, have been under uniform tests at the Agricultural College in each of the past five years. The experiment was conducted on what might be termed an average clay loam. In part of the years the plots were located on a ridge and in other years on lower, sloping land. The following table gives the average results of the five years' experiment with each of twenty-one varieties of spring wheat:

Varieties.	Bearded or Bald.	Average Height (inches).	Per cent Rust.	Days to reach Maturity.	Weight per Measured Bushel (pounds).	Yield per Acre.	
						Straw (tons).	Grain (bus.)
Flour Wheats.							
Saxonka	Bearded	48	10	116	60.94	2.52	38.88
Pringle's Champion	Bearded	48	8	116	60.99	2.58	38.31
Climax	Bearded	47	7	115	60.01	2.63	38.27
Marquis	Bald	41	12	111	61.27	2.09	37.54
Minnesota No. 163	Bald	46	8	115	58.75	2.35	36.47
Herison Bearded	Bearded	45	7	115	61.49	2.47	36.38
White Russian	Bald	44	8	115	58.51	2.37	36.10
Hungarian	Bearded	42	10	111	61.86	2.28	36.02
Red Fife	Bald	44	9	115	58.84	2.33	35.24
Red Fern	Bearded	48	9	115	60.34	2.38	35.09
White Fife	Bald	42	10	117	57.96	2.29	34.58
Colorado	Bearded	46	8	114	60.52	2.29	33.53
Prelude	Bearded	35	18	102	62.10	1.58	27.08
Durum Wheats.							
Arnautka	Bearded	46	4	114	62.66	2.14	40.28
Roumania	Bearded	46	4	115	62.29	2.07	39.38
Wild Goose	Bearded	46	3	114	62.30	2.19	38.90
Kubanka	Bearded	47	4	115	61.87	2.11	37.44
Sorentina	Bearded	46	4	112	61.09	2.10	34.42
Medeah	Bearded	45	4	111	61.35	2.02	33.19
Turgid Wheat.							
Seven Headed	Bearded	47	13	117	60.22	2.30	31.74
Polish Wheat.							
Polish	Bearded	42	9	116½	57.19	1.95	24.26

The Saxonka, the Pringle's Champion and the Climax, which occupy the three highest places in yield per acre of the flour wheats, are not grown extensively in Ontario. The Marquis variety of spring wheat, which occupies fourth place in average yield per acre, is a hybrid wheat originated at the Central Experimental Farm, Ottawa, from crossing the Calcutta Hard Red and the Red Fife. It is not only a good yielder, but it is a wheat of excellent quality for bread production and one which is increasing substantially in the Western Provinces and in Ontario. It occupies a somewhat similar position amongst the spring wheats as does the O.A.C. No. 21 barley, the O.A.C. No. 72 oats and the O.A.C. No. 61 spring rye amongst other classes of spring grain. Of the Durum wheats, the Wild Goose variety has been grown for many years in Ontario, and is popular amongst the farmers. The Arnautka is very similar to the Wild Goose but is not grown much in Ontario under that name.

In each of the years 1915 and 1916, the varieties of spring wheat were milled and uniform quantities of flour were tested for bread production in the Bakery branch of the Chemical Department at the College. The leading varieties in volume of loaf are given in the following order: Prelude, Marquis, White Fife, White Russian, Hungarian and Minnesota No. 163. Those varieties which produced the lowest volume of bread were Polish, Seven Headed and Medeah. The Prelude, which came first in size of loaf, was also originated at the Central Experimental Farm. The Saxonka, which secured highest place of the flour wheats in average yield of grain per acre for five years, occupied fourteenth place in comparative size of loaf in the baking tests of two years, but in this respect slightly surpassed both the Pringle's Champion and the Climax varieties.

A new hybrid variety of spring wheat has been originated at our College by crossing the Red Fife and the Herison Bearded varieties, and it has given an average yield of grain of 40.7 bushels per acre per annum in the experiments for the last five years. This is a higher average yield per acre than any of the named varieties. In comparative size of loaf, from a definite quantity of flour, it was surpassed by nine of the twenty-one named varieties reported in the previous table. This new variety has not been distributed for general cultivation.

Seven varieties of flour wheats have been under test at the College in each of the past twenty-seven years. It might be interesting to compare the yields per acre, in periods of nine years, of these separate varieties with the yields of all varieties in general cultivation over the Province, as determined by the Ontario Bureau of Industries and as referred to in an earlier portion of this bulletin:

Varieties.	Annual Yield per Acre. (Bus.)			
	1891-1899 Average 9 years.	1900-1908 Average 9 years.	1909-1917 Average 9 years.	1891-1917 Average 27 years.
Saxonka	30.7	33.6	35.0	33.1
Red Fife	29.4	33.6	33.3	32.1
Pringle's Champion	28.0	33.7	33.9	31.9
White Russian	29.6	32.6	32.1	31.4
Red Fern	29.4	33.0	31.8	31.4
Herison Bearded	30.0	31.7	32.2	31.3
Colorado	26.3	31.1	29.6	29.0
Average seven varieties	29.1	32.8	32.6	31.5

The Saxonka has the highest record in average yield of grain per acre of thirteen named varieties of flour wheat tested for five years, and also of seven varieties tested for twenty-seven years in succession. An average record of 31½ bushels of spring wheat per acre, representing seven varieties grown in the experimental grounds at the Ontario Agricultural College in each of the past twenty-seven years, shows that spring wheat can still be grown in Ontario with a considerable amount of success.

It is interesting to know that each of these seven varieties of spring wheat were grown at the College for twenty-seven years in succession without any plant selection and without any change of seed from an outside source during that period of time. It shows that with care in sowing, nothing but good seed varieties of spring wheat may be grown on the same farm in Ontario for a long period of time without change of seed and without any marked decrease in yield of grain per acre.

SEED SELECTION OF SPRING WHEAT.

Experimental work in seed selection with spring wheat was conducted at the Ontario Agricultural College in each of eight years. The two varieties used were the Herison Bearded and the Bart Tremenia. As in the case of winter wheat, the selections were not continuous throughout the whole period, but they were made from a bulk lot of spring wheat each year. As this experiment was repeated in so many different seasons, a knowledge of the immediate influence from the different selections should prove of real service to the growers of spring wheat. A uniform number of seeds for the different selections were used. The following table gives the average results of each of three selections of spring wheat conducted over a period of eight years:

Selections.	Yield of Straw per Acre (tons).	Weight of Grain per Measured Bushel (pounds).	Yield of Grain per Acre. (bushels).
Large plump seed	1.4	59.1	21.7
Small plump seed	1.3	58.3	18.0
Shrunken seed	1.2	56.9	16.7

The large, plump seed gave the best results in yield of both straw and grain per acre and in weight of grain per measured bushel. The results show that large, plump seed gave an increase over small, plump seed of about 20 per cent., and over shrunken seed of about 30 per cent. This shows the importance of cleaning and grading spring wheat so as to secure the large, plump, sound grain to be used for seed if the highest returns are to be expected.

SOWING SPRING WHEAT AT DIFFERENT DATES.

For five years in succession an experiment was conducted at the Ontario Agricultural College in sowing spring wheat at six different dates in the spring, commencing as early as the land could be worked satisfactorily and allowing one week between each two dates of sowing. In each year the experiment was conducted in duplicate by sowing one plot at each date of seeding with the grain drill and another plot broadcast by hand. The average results of the ten separate tests conducted in the five-year period are as follows:

Seedings.	Yield of Straw per Acre (tons).	Weight of Grain per Measured Bushel (pounds).	Yield of Grain per Acre (bushels).
1st	1.2	60.1	21.9
2nd	1.1	59.6	19.2
3rd........................	1.0	59.0	15.4
4th........................	.9	58.9	13.0
5th........................	.6	56.5	8.4
6th........................	.8	54.0	6.7

The varieties of grain used in this experiment were the Pringle's Champion and the Herison Bearded. The earliest seeding gave the best results throughout. It is interesting to note that there was a gradual decrease in crop production as the dates advanced from the beginning to the end of the test. According to the results of the experiment, there was an average decrease in yield of spring wheat per acre of 26.1 pounds for each day's delay after the first seeding took place. Of all spring cereals grown in Ontario, wheat should be sown earliest. It is therefore essential, if the best results are to be obtained, to sow spring wheat as early in the spring as the season will permit.

CULTURAL METHODS.

Spring wheat thrives on almost any fertile soil which is well drained and in a good state of cultivation. As a rule, however, it does not give as large returns on a sandy or a gravelly soil.

Tests have been made at the College in comparing the results in growing spring wheat after potatoes and fall turnips for each of three years, and after corn, swede turnips, carrots and rape for one year. The results show very good yields of spring wheat per acre after each of these cultivated crops, and particularly good returns after potatoes and corn. It is of great importance to have land either ploughed or cultivated in the autumn so as to permit of early seeding of the wheat in the following spring.

Spring wheat was sown at the College with a tube drill and broadcast by hand on well cultivated land at each of six different dates in each of five years. The results go to show that in yield of grain per acre of the five separate dates for which we have complete returns, the drilled grain gave the highest yields in the average of each of four dates, and the grain which was sown broadcast by hand gave the highest returns in the average of one date. In averaging the results for all dates of sowing, there was but slight difference in the returns from the two methods of seeding. If the land had been poorly prepared and lumpy, it is quite likely that the grain which was sown with the tube drill would have produced a considerably higher yield than that which was sown broadcast.

SPRING WHEAT USED AS A PASTURE AND IN MIXTURES.

In each of five years fourteen different classes of spring crops were sown on uniform plots to determine the amount of pasture material which could be obtained. Each of the crops was cut and weighed every three weeks throughout the summer. The average results for the five years show that the spring cereals gave the following amount of green pasture per acre annually: Oats, 8.7 tons; spring rye, 7.4 tons; barley, 6.8 tons; and spring wheat, 5.2 tons. The oats gave the highest amount of pasture and the spring wheat the second lowest amount of pasture of the fourteen kinds of crops under test.

Some farmers seem to be of the opinion that by adding spring wheat to a seeding mixture of oats and barley for grain production they do not reduce the yield of oats and barley per acre, and that they get a fair yield of spring wheat in addition. In our experiments at Guelph, we have obtained particularly good results from a mixture of oats and barley. An experiment was conducted in duplicate in each of five years to ascertain whether any other grains could be added to a mixture of oats and barley to furnish an increase in the yield. In the average of ten tests made in five years, it was found that one bushel of oats and one and one-half bushels of barley sown per acre gave a yield of 2,612 pounds, and that a mixture of one bushel of oats, one and one-half bushels of barley and one-half bushel of Wild Goose spring wheat sown per acre gave a yield of 2,512 pounds of mixed grain. It will, therefore, be seen that by adding one-half bushel of spring wheat to the seeding mixture the resultant crop was reduced by exactly one hundred pounds per acre.

EMMER, SPELT AND EINKORN.

Emmer and spelt are used in some countries to a limited extent for flour production. When used for this purpose, however, special machinery is required for separating the chaff or the hull from the grain, as the grain is usually surrounded by the chaff after being threshed. In this country these grains are considered from the standpoint of the amount of feed which they will produce for farm stock. Emmer is about equal to barley for feeding purposes. The following table gives the average results of growing at the College each of three varieties of emmer and of four varieties of spelt over a period of sixteen years:

Classes of Crop.	Varieties.	Average Results for 16 years.					
		Per cent. of Rust.	Per cent. of Crop Lodged.	Per cent. of Hull.	*Weight per Measured Bushel (pounds).	Yield per Acre.	
						Straw (tons).	Grain (pounds)
Emmer	Iowa	2	22	19.7	39.6	1.84	2,906
	Common	2	25	20.2	39.4	2.05	2,869
	Russian	2	20	20.4	39.6	1.83	2,758
Spelt	Red	12	5	28.8	27.7	1.68	2,120
	Alstroum	16	3	29.5	27.3	1.61	2,100
	White	15	3	30.1	27.1	1.58	2,009
	Bearded	13	11	27.4	28.7	1.64	1,935

*Average results for 15 instead of 16 years.

The emmer surpassed the spelt in freedom from rust, thinness of hull, weight of grain per measured bushel and in yield of both straw and grain per acre. The spelt, however, surpassed the emmer somewhat in strength of straw. The Iowa emmer, which has the smallest percentage of hull of the varieties included in this test, gave the greatest number of pounds of grain per acre.

A co-operative experiment was conducted over Ontario in each of four years in which tests were made on ninety-three separate farms, comparing the average yield in pounds per acre of O.A.C. No. 21 barley and Common emmer under similar conditions. The following were the average yields of grain per acre per annum of all the tests made in the four years: O.A.C. No. 21 barley, 1,673 pounds, and Common emmer, 1,402 pounds. The barley surpassed the emmer in grain production in each of the four years.

Black winter emmer has been grown under test at the College in each of the past ten years, and has given an average annual yield of 2.1 tons of straw and of 2,345 pounds of grain. The average weight per measured bushel of the grain, including the hull, was 27.6 pounds. This yield is somewhat lower than the average yields of the spring varieties of emmer. The yield of grain in pounds per acre has varied from 138 in 1912 to 4,146 in 1915.

The average results of an experiment extending over a period of ten years show that in average yield of grain per acre per annum, the Common emmer gave 2,644 pounds and the Einkorn 1,780 pounds. It will be seen that the Einkorn which is mentioned in the earlier part of this bulletin as a distinct type of wheat, is not of any special agricultural value as a grain producer in this Province.

DATES OF SOWING EMMER AND SPELT.

In each of five years both emmer and spelt were sown on eight different dates in the spring, by making the first date in the season as early as the land was suitable for cultivation. One week was allowed between each two dates of seeding. The Common Emmer and the Red Spelt were the special varieties used. The average results of the experiment for five years are presented in the following table:

Dates of Seeding.	Average Results for five years.					
	Pounds per Measured Bushel.		Tons of Straw per Acre.		Pounds of Grain per Acre.	
	Spelt.	Emmer.	Spelt.	Emmer.	Spelt.	Emmer.
First	28.3	40.1	1.6	1.9	2,377	2,747
Second	27.3	39.1	1.6	2.0	2,163	2,848
Third	26.3	39.1	1.7	2.0	1,898	2,646
Fourth	24.9	37.6	1.6	2.1	1,582	2,754
Fifth	24.2	36.7	1.5	2.1	1,287	2,509
Sixth	21.6	36.1	1.6	2.3	983	2,465
Seventh	19.6	35.4	1.5	2.4	685	2,312
Eighth	19.9	34.0	1.5	1.9	499	1,953

The figures representing the pounds per measured bushel and the pounds of grain per acre include the chaff or hull surrounding the grain, as well as the grain itself. In the examination of the results here presented, the reader will be impressed with the superiority of the emmer as compared with the spelt in weight of grain per measured bushel, and in yield of both straw and grain per acre. In no instance does the spelt show a better record than the emmer. It will be noticed that even the fourth seeding of emmer produced a higher yield of grain per acre than that obtained from the first seeding. The results seem to indicate that emmer may be sown at a later date than the ordinary varieties of spring wheat.

RYE.

In Canada and in the United States rye is principally used as a feed for farm stock, but in Europe it is used extensively for bread production. Rye is more hardy than wheat and can be grown in more extreme northern latitudes. At the Ontario Agricultural College, winter wheat sometimes becomes winter killed, but winter rye practically always survives without injury. According to the report of the Bureau of Industries for Ontario, the following average annual number of acres of rye grown in this Province in each of four periods of nine years is as follows:

Periods.	Years.	Average Number of Acres of Rye grown in Ontario annually.
1882-1890...........	9	107,610
1891-1899...........	9	117,700
1900-1908...........	9	126,219
1909-1917...........	9	122,081

In 1917 there were 133,077 acres of rye produced in this province. The average yield in bushels of rye per acre in Ontario is given as 17.0 for the last three, and as 16.5 for the past thirty-six years. The statistics gleaned by the Bureau of Industries for rye are for all varieties, and no distinction is made between those which were sown in the autumn or in the spring.

According to the agricultural statistics of Canada for the past two years, Ontario has thirty-eight per cent. of the acreage of the rye of the Dominion.

In 1916, of all the States of the American Union, each of nine had a greater acreage of rye than the Province of Ontario. The annual average yield in bushels of rye per acre for the whole of the United States, from 1906 to 1915 inclusive, is given as 16.2.

VARIETIES OF WINTER RYE.

Four varieties of winter rye have been under test at the Ontario Agricultural College in each of the past fourteen years. The following gives the average results for the whole period:

Varieties.	Per cent. of Crop Lodged.	Weight per Measured Bushel (pounds).	Yield per Acre.	
			Straw (tons).	Grain (bushels).
Mammoth White................	12	57.2	3.9	55.8
Washington	22	57.3	3.7	53.0
Common	11	57.4	3.8	52.0
Thousand Fold..................	19	57.0	3.8	51.4

It will be seen that all varieties of winter rye have produced a high average yield of grain per acre. It should be understood that these have been grown on similar soil to that used for the other cereals. In many cases over Ontario, winter rye is sown on land which is so poor that it will scarcely grow any other crop. If winter rye were sown under similar conditions as winter wheat over Ontario, the yields per acre would surprise many farmers.

For six years in succession the Petkus variety of winter rye has been included in the experiments and has surpassed all other kinds with two slight exceptions in each of the six years. The average yield per acre per annum of the Petkus winter rye surpassed that of the next highest yielding variety by 4.7 bushels.

Petkus winter rye was distributed throughout Ontario for co-operative experiments in the autumns of 1914 and 1915 with Imperial Amber winter wheat, and in 1916 with American Banner winter wheat. The average results show that the rye surpassed the winter wheat by 380 pounds in 1915, 344 pounds in 1916, and 240 pounds in 1917.

WINTER RYE AS A NURSE CROP FOR HAIRY VETCHES.

In each of two years three plots of Hairy Vetches, with some other kind of grain, have been tested at the Agricultural College for seed production. The Hairy Vetches were used at the rate of 60 pounds per acre throughout and were mixed with other grains as follows: Petkus winter rye, 56 pounds; Dawson's Golden Chaff winter wheat, 60 pounds; and Black Winter emmer, 40 pounds. The average results for the two years are here presented:

Mixtures.	Average Yield per Acre (pounds.)	
	Vetches.	Cereals.
Hairy Vetches and Winter Rye	489	1705
Hairy Vetches and Winter Wheat	337	849
Hairy Vetches and Winter Emmer	422	286

These results show that Hairy Vetches and Winter rye grow very satisfactorily when sown in combination. In some places in the southern extremity of the Province, Winter rye and Hairy Vetches are now grown in combination with much satisfaction. The combination might be used for different purposes, and especially as a cover crop for orchards. The rye makes an excellent nurse crop for vetches when it is desirable to produce the seed of Hairy Vetches in Ontario.

In another experiment which was conducted in each of the past two years by sowing in combination three different quantities of Hairy Vetches and three different quantities of Petkus winter rye per acre for seed production, the average results show that in yield per acre of both the winter rye and the Hairy Vetches the highest returns were obtained by using 60 pounds of the former and 50 pounds of the latter, or a mixture of 110 pounds of seed per acre.

WINTER RYE AS A PASTURE AND AS A FODDER CROP.

Winter rye, when sown in August or very early in September, is frequently pastured to a limited extent in the fall or in the spring, and occasionally it is pastured in both seasons and afterwards allowed to produce either a crop of fodder or a crop of grain. Winter rye forms an excellent grazing crop in the autumn, and especially for milk production. The special advantage of sowing winter rye in the autumn for pasture or for green fodder in the spring is the fact that it will furnish a considerable amount of green material earlier in the spring than other forage plants and before the pasture grasses are available. Experiments are now under way at the College in the sowing of winter rye in the spring of the year for summer pasture. When winter rye is sown in the spring, it gives a heavy leaf development but produces only a very small amount of grain. As yet sufficient work has not been carried on to furnish results for publication.

Green rye has been placed in the College silo on two or three occasions, but it has been found very difficult to make good rye silage. This is probably owing to the hollow stems of rye holding considerable air and, therefore, not forming as compact a body of material as some of the other crops such as corn.

A co-operative experiment was conducted on different farms over Ontario in testing winter rye for the production of green fodder. In the average of five years' experiments, the winter rye gave 7.93 tons per acre per annum.

CULTURAL METHODS FOR WINTER RYE.

Rye does particularly well on clay or sandy loam soils, and better than wheat or barley on poor soils and under unfavorable climatic conditions. All soils for rye, however, should be well underdrained. It is claimed that rye has a greater water requirement than any other cereal except oats.

Winter rye occupies about the same place in a rotation and requires about the same preparation of soil as winter wheat. As rye is not a heavy stooler, eight pecks per acre is frequently sown. Although best results are usually obtained in Ontario from sowing winter rye in the early part of September, it is frequently not sown until the latter part of the month or even into the month of October. Rye will stand later seeding than winter wheat without serious injury.

VARIETIES OF SPRING RYE.

Statistics are not collected in Ontario in regard to the relative proportions of spring and winter rye which are grown. The spring varieties, however, are grown to a limited extent, although the yields per acre are not usually as large as those obtained from sowing in the autumn. An experiment has been conducted at the College with four varieties throughout the past ten years, with the following results:

Varieties.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons.).	Grain (bushels).
O. A. C. No. 61	54.0	2.2	30.1
Saatroggen	54.4	2.2	29.6
Prolific	54.2	2.0	26.6
Common	53.9	2.1	26.3

The O.A.C. No. 61 variety of spring rye was obtained through selection of individual plants from a variety of winter rye obtained from Germany.

A co-operative experiment with two varieties of spring rye was conducted over Ontario in each of the past seven years. The following gives the average yields per acre in each of the years and for the whole period:

Varieties.	Average Yield of Grain per Acre (bushels).							
	1911.	1912.	1913.	1914.	1915.	1916.	1917.	Average 7 years.
O. A. C. No. 61	17.9	26.8	20.0	25.4	18.2	42.1	22.5	24.7
Common	16.3	24.5	15.9	25.0	12.5	36.4	20.4	21.6

In the average of these co-operative tests conducted on thirty farms throughout Ontario, it will be seen that the O.A.C. No. 61 surpassed the Common variety of rye in each of the seven years. The average yield for the whole period was 3.1 bushels per acre per annum in favor of the former.

SEED SELECTION OF SPRING RYE.

In each of the six years, from 1912 to 1917 inclusive, different selections of seed of spring rye have been tested at the College under similar conditions. Careful selections were made from a bulk lot of rye each spring and a uniform number of seeds were used for each plot. The following table gives the average of six years' results of the different selections:

Selections.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons).	Grain (bus.).
Large seed	53.3	2.0	26.0
Medium seed	53.3	2.0	24.4
Small seed	53.5	1.9	22.3
Broken seed	52.8	1.6	16.9

It will be seen that the influence of selection of seed in spring rye is not quite as marked as in the case of either winter wheat or spring wheat. The results, however, of this experiment, as well as all others which we have conducted in seed selection, show the importance of thoroughly cleaning grain so as to get the very best seed possible if the highest returns are to be obtained.

CONCLUSION.

This bulletin on "Wheat and Rye" is submitted to the farmers of Ontario with the expectation of the writer that it will prove of real service in increasing the production of essential food materials. These important grains might be considerably increased in this Province without the requirement of much additional labor. The increased production of wheat and rye occupies the unique position of filling a world-wide need and of furnishing greater remuneration to the growers.

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